

Surveying the MeV gamma-ray sky with AMEGO-X

Henrike Fleischhack

Code 661, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD, USA

E-mail: henrike.fleischhack@nasa.gov

for the AMEGO-X team

Abstract. Recent detections of gravitational wave signals and neutrinos from gamma-ray sources have ushered in the era of multi-messenger astronomy, while highlighting the importance of gamma-ray observations for this emerging field. AMEGO-X, the All-sky Medium Energy Gamma-Ray Observatory eXplorer, is an MeV gamma-ray instrument proposed to the 2021 call for medium-sized explorer missions. AMEGO-X will survey the sky in the energy range from 100 keV to 1 GeV with unprecedented sensitivity, as well as detecting and localizing transient events such as gamma-ray bursts and magnetar activity down to 25 keV. AMEGO-X will detect gamma-ray photons both via Compton interactions and pair production processes, bridging the "sensitivity gap" between hard X-rays and high-energy gamma rays. AMEGO-X will provide important contributions to multi-messenger science and time-domain gamma-ray astronomy, studying e.g. high-redshift blazars, which are probable sources of astrophysical neutrinos, and gamma-ray bursts. I will present an overview of the instrument and anticipated science program.

1. Introduction

What do gamma-ray bursts, active galaxies, and Galactic supernova remnants have in common? All of these objects are potential multi-messenger sources, meaning that they are thought (or proven) to emit more than one kind of astrophysical messenger¹. But also, all of them are gamma-ray sources — and in particular, sources of gamma rays in the MeV energy range. The MeV band is rather challenging due to the relatively small cross section and the complex event reconstruction, and is under-explored compared to the neighboring X-ray and GeV gamma-ray bands. Yet, this band is absolutely crucial to understanding the multi-messenger cosmos.

Enter AMEGO-X, the All-sky Medium Energy Gamma-Ray Observatory eXplorer. AMEGO-X is an MeV gamma-ray mission designed for multi-messenger studies. It has been designed to answer three main science questions:

- How do binary neutrons star mergers produce relativistic jets?
- Do supermassive black holes accelerate cosmic rays and produce neutrinos?
- Where are cosmic rays accelerated in the Galaxy

AMEGO-X will answer these questions by surveying the MeV gamma-ray sky from about 100 keV to about 1 GeV every few hours, monitoring the lightcurves and spectra of variable

¹ The four currently known astrophysical messengers are photons/electromagnetic waves, cosmic rays (charged particles), neutrinos, and gravitational waves.

gamma-ray sources such as active galactic nuclei. Over its three year mission duration, AMEGO-X will detect new gamma-ray emitters and both inside and outside the Galaxy, and will provide improved spectral measurements of known gamma-ray sources, in particular below 100 MeV. These measurements will allow to constrain the particle acceleration mechanisms.

AMEGO-X will also be able to detect transient gamma-ray phenomena such as gamma-ray bursts produced by binary neutron star mergers down to 25 keV and measure their positions, energy spectra, and light curves. Transient alerts, including localization to 2° or better, will be provided ground alert systems within 30 s for most transients, enabling rapid follow-up observations in other wavelengths. We expect to detect a handful of gamma-ray bursts in coincidence with gravitational wave signals seen by gravitational wave detectors.

More information on the AMEGO-X detector and mission can be found in [1] and [2]. Specific science cases are detailed in [3] and [4].

2. Status and Next Steps

AMEGO-X was proposed to NASA's MIDEX AO in December 2021. Unfortunately, it was not selected for further funding as a MIDEX mission at this time. The AMEGO-X team continues to develop the technology and science case and aims to re-propose the mission to upcoming opportunities.

One major innovation compare to prior similar detectors is the use of monolithic active pixelated silicon (MAPS) sensors in the AMEGO-X tracker. MAPS provide 3D position readout for each particle interaction with good angular resolution and a low noise floor. AstroPix [5] is a MAPS concept for gamma-ray astronomy. The current status of AstroPix development and testing is laid out in [6]. The current funding cycle will culminate in a sounding rocket launch in 2024, which will space-qualify the sensor. A larger prototype is foreseen for the following years.

3. References

- [1] H. Fleischhack. AMEGO-X: MeV gamma-ray Astronomy in the Multi-messenger Era. In *Proceedings of the 36th International Cosmic Ray Conference*, volume ICRC2021, page 649, 2021.
- [2] Regina Caputo et al. The All-sky Medium Energy Gamma-ray Observatory eXplorer (AMEGO-X) Mission Concept. *submitted to JATIS*, 8 2022.
- [3] I. Martinez-Castellanos et al. Improving the Low-energy Transient Sensitivity of AMEGO-X using Single-site Events. *The Astrophysical Journal*, 934(2):92, jul 2022.
- [4] Tiffany R. Lewis et al. Modeling and Simulations of TXS 0506+056 Neutrino Events in the MeV Band, 2021.
- [5] I. Brewer et al. Developing the future of gamma-ray astrophysics with monolithic silicon pixels. *Nucl. Instrum. Meth. A*, 1019:165795, 2021.
- [6] A. L. Steinhebel et al. AstroPix: Novel monolithic active pixel silicon sensors for future gamma-ray telescopes, 2022.